Remote Sensing of Mining

EPA

Garnet Hill

Lane (Mineral) City

Hwy 50

Keystone Corner

Old Ruth

Future site of New Ruth

Keystone Dump

Lone Tree Addition

Copper Flat

Liberty Pit

Riepetown

Future site of Magma / BHP office, mill, crusher
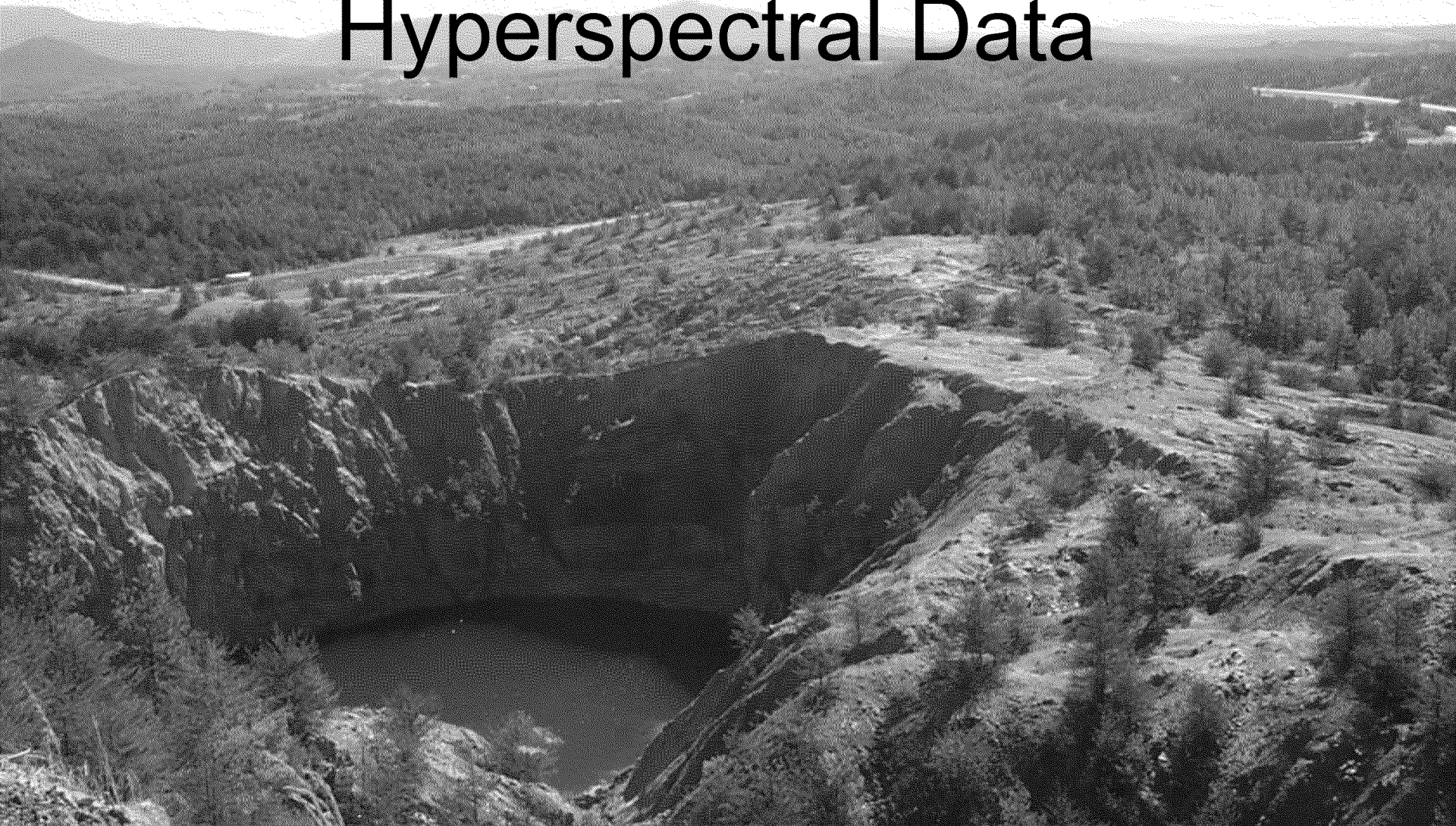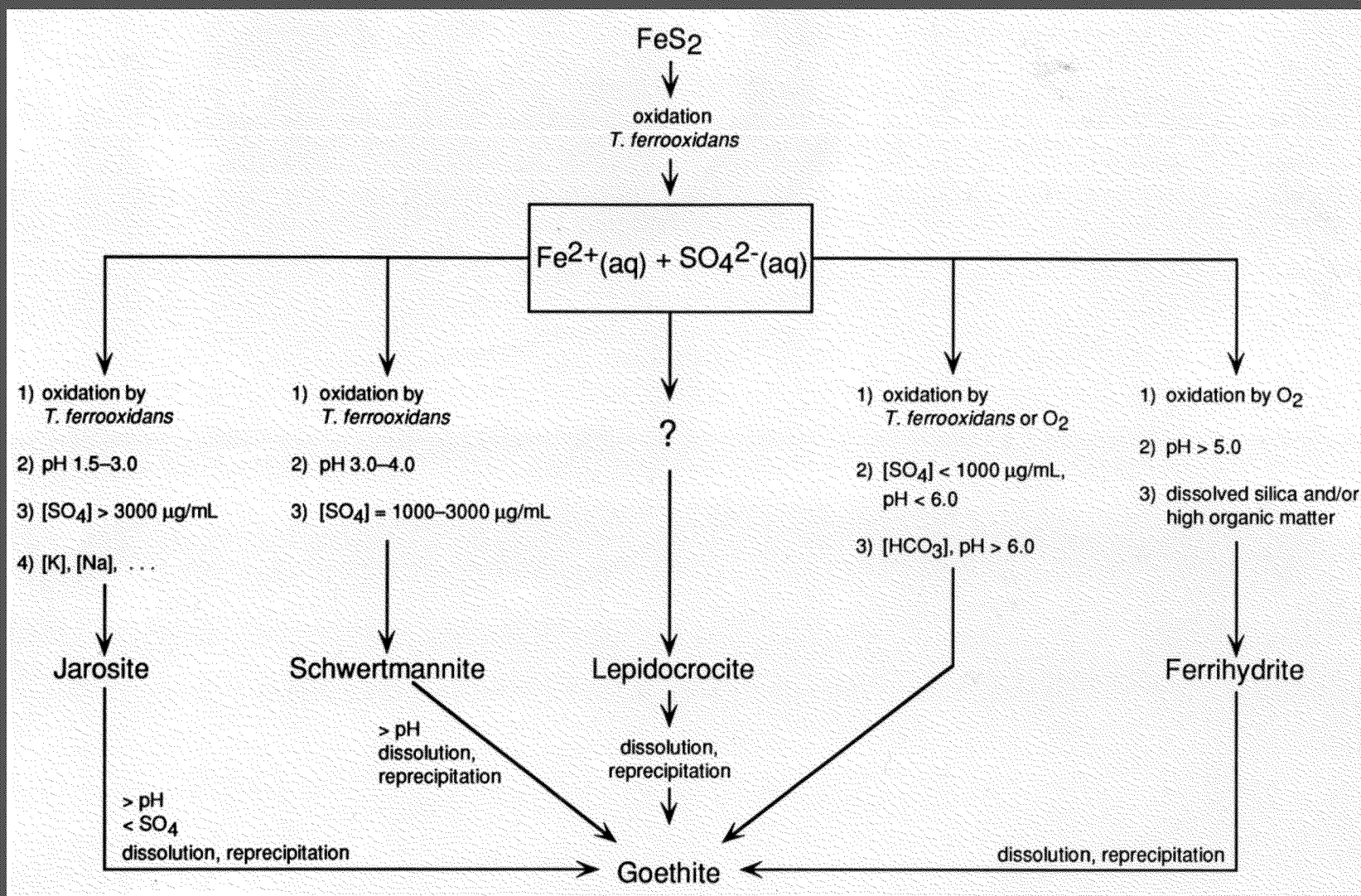
Remote Sensing Imagery

- Identification of mining operations
  - map the extent, changes over time
- Identification of tailings, overburden piles
- Determination of water quality degradation
  - mapping of acid mine drainage sediments
  - coal fines accumulation
  - watercourse diversions

Determining Water Quality in Mine-Impacted Areas using Hyperspectral Data
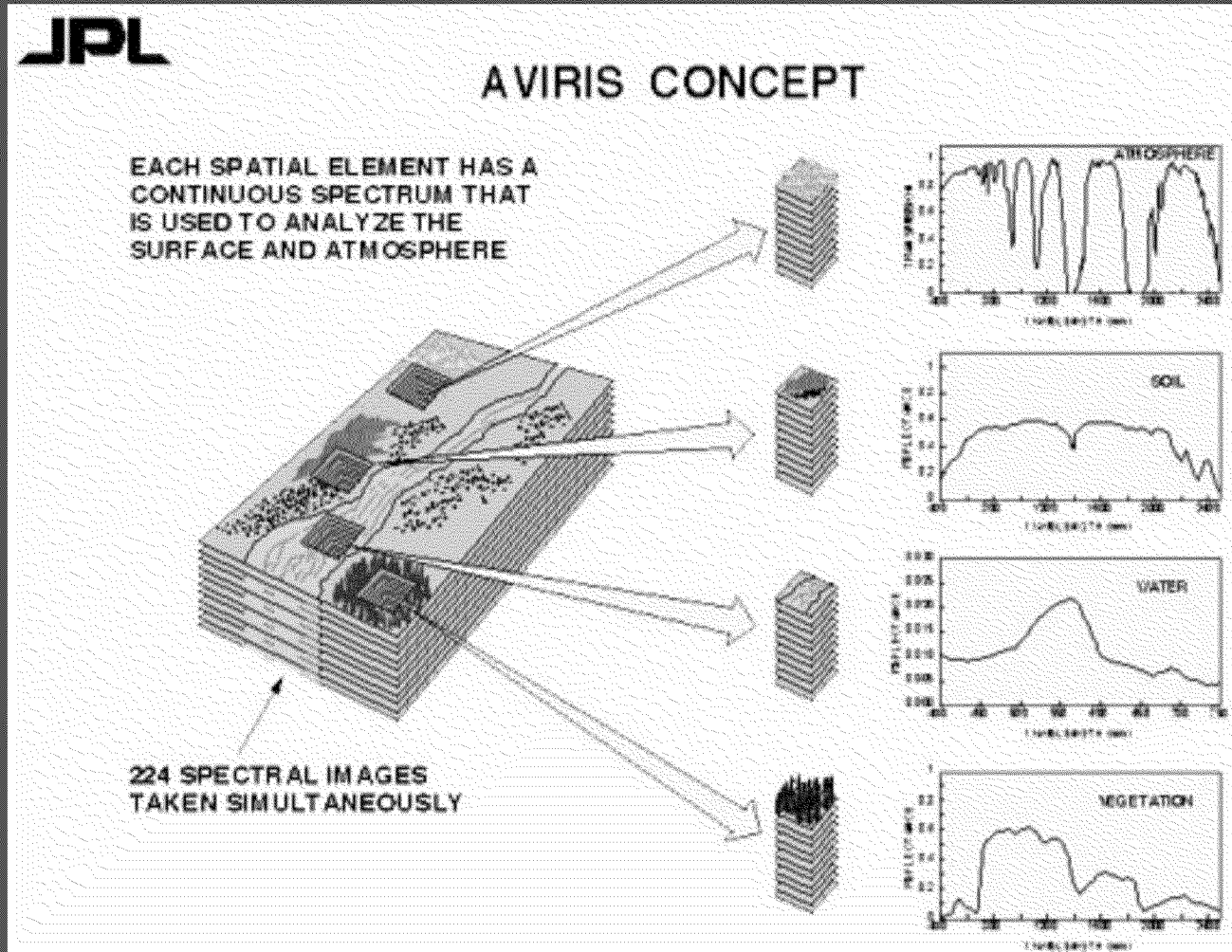
Biogeochemical model

FeS$_2$

$\downarrow$

oxidation
T. ferrooxidans

$\downarrow$

Fe^{2+}(aq) + SO$_4$$^{2-}$(aq)

1) oxidation by *T. ferrooxidans*

2) pH 1.5–3.0

3) [SO$_4$] > 3000 μg/mL

4) [K], [Na], . . .

$\downarrow$

Jarosite

1) oxidation by *T. ferrooxidans*

2) pH 3.0–4.0

3) [SO$_4$] = 1000–3000 μg/mL

$\downarrow$

Schwertmannite

> pH
dissolution, reprecipitation

?

$\downarrow$

Lepidocrocite

dissolution, reprecipitation

$\downarrow$

1) oxidation by *T. ferrooxidans* or O$_2$

2) [SO$_4$] < 1000 μg/mL, pH < 6.0

3) [HCO$_3$], pH > 6.0

1) oxidation by O$_2$

2) pH > 5.0

3) dissolved silica and/or high organic matter

$\downarrow$

Ferrihydrite

> pH
< SO$_4$
dissolution, reprecipitation

dissolution, reprecipitation

Goethite

Imaging Spectroscopy

These spectra are used to derive information based on the signature of the interaction of matter and energy expressed in the spectrum.


JPL

AVIRIS CONCEPT

EACH SPATIAL ELEMENT HAS A CONTINUOUS SPECTRUM THAT IS USED TO ANALYZE THE SURFACE AND ATMOSPHERE

ATMOSPHERE

SOIL

WATER

VEGETATION

224 SPECTRAL IMAGES TAKEN SIMULTANEOUSLY

Imaging Spectroscopy at Copper Basin TN

- Mining of massive sulfide ores (iron and copper) began in 1850
- Two major mining companies
  - Cities Service Company
  - Tennessee Chemical Company (declared bankrupt in 1989)
- 1891 open heap roasting of copper ore began. 15 years later all vegetation was destroyed.
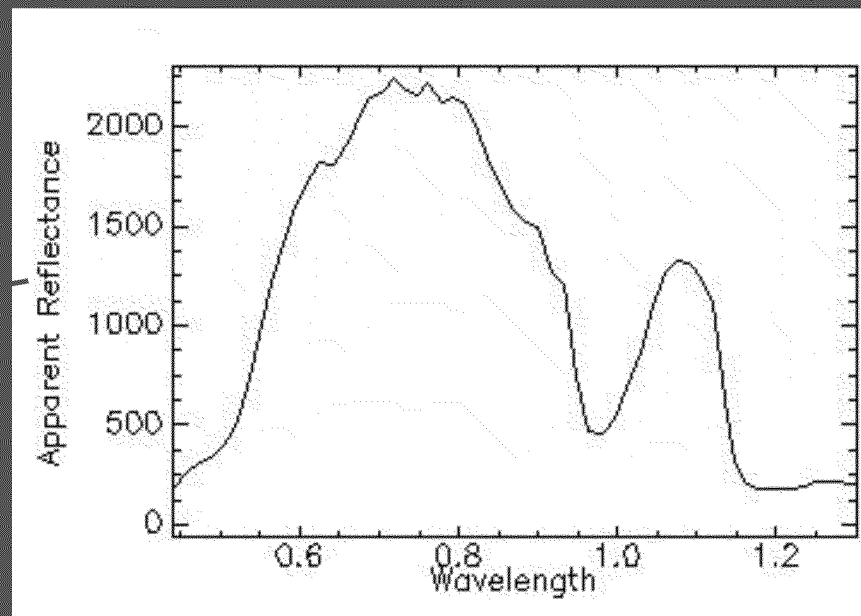
Mine drainage impacted stream at Copper
Basin, TN

Methods

Large tailings pond

Ducktown

Copper Hill

Ocoee River
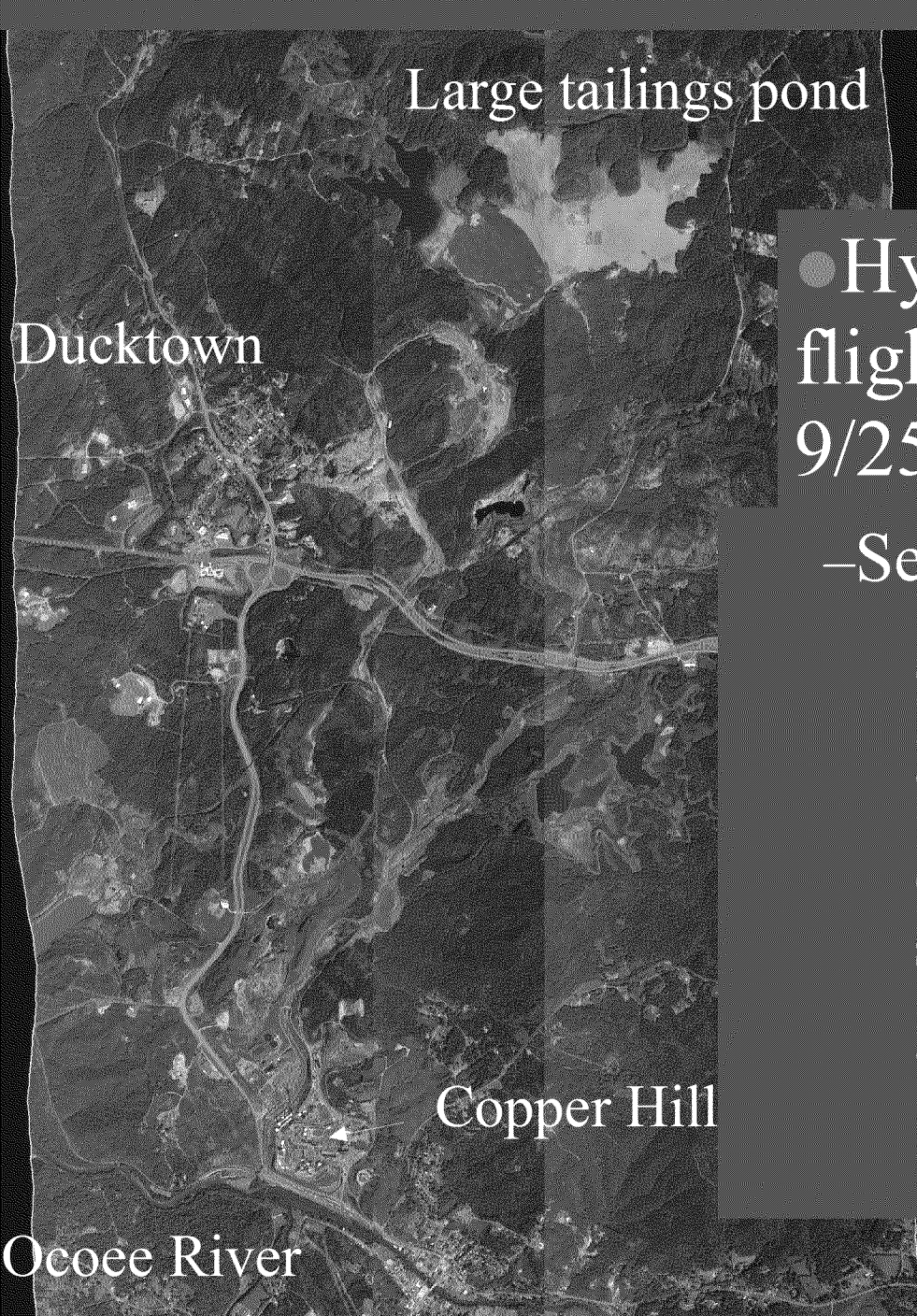
- HyMap sensor flew three flight lines over the area on 9/25/99
  - Sensor characteristics:
    - 126 spectral bands: 0.45 – 2.5 nm
    - 15nm bandwidths
    - Ground sampling distance (pixel size): 5 meter
   - Signal to noise ratio > 500:1

Copperhill

Results

- Mine drainage sediments in the North Potato Creek and Davis Mill Creek are comprised of schwertmannite with trace to small amounts of goethite
  - These minerals form in acid sulfate systems
- The pH of these stream reaches can be estimated to be pH 3-4 with moderate to high dissolved sulfate loads
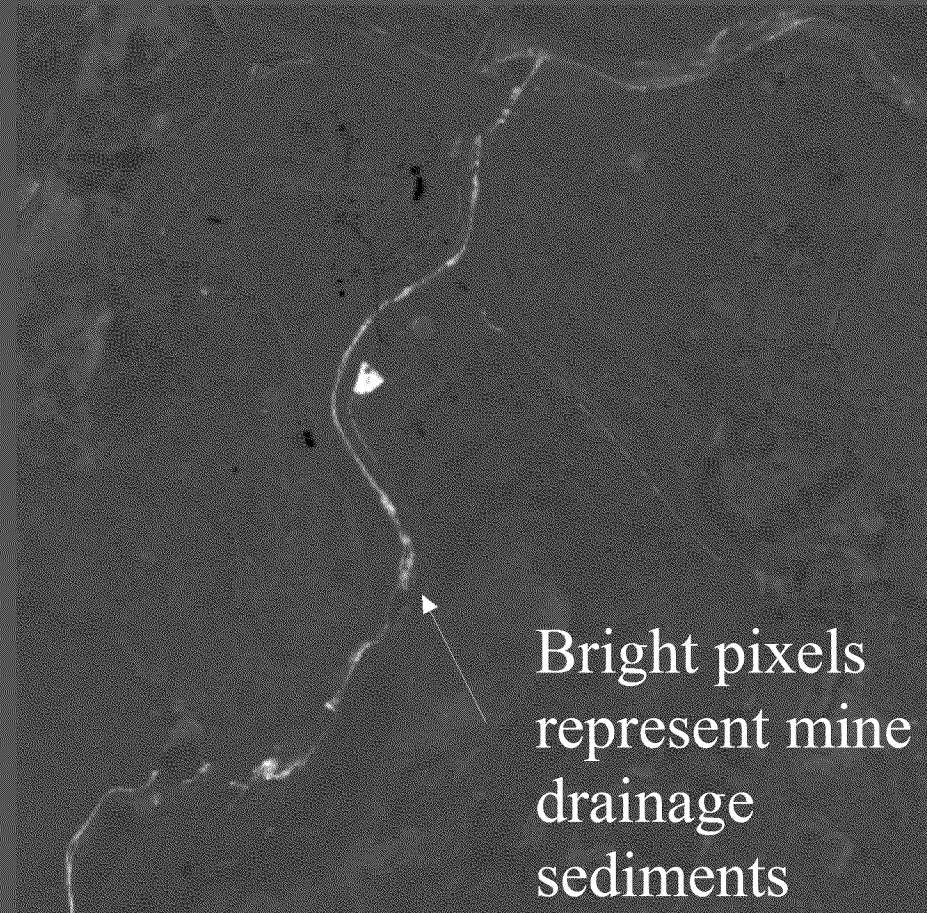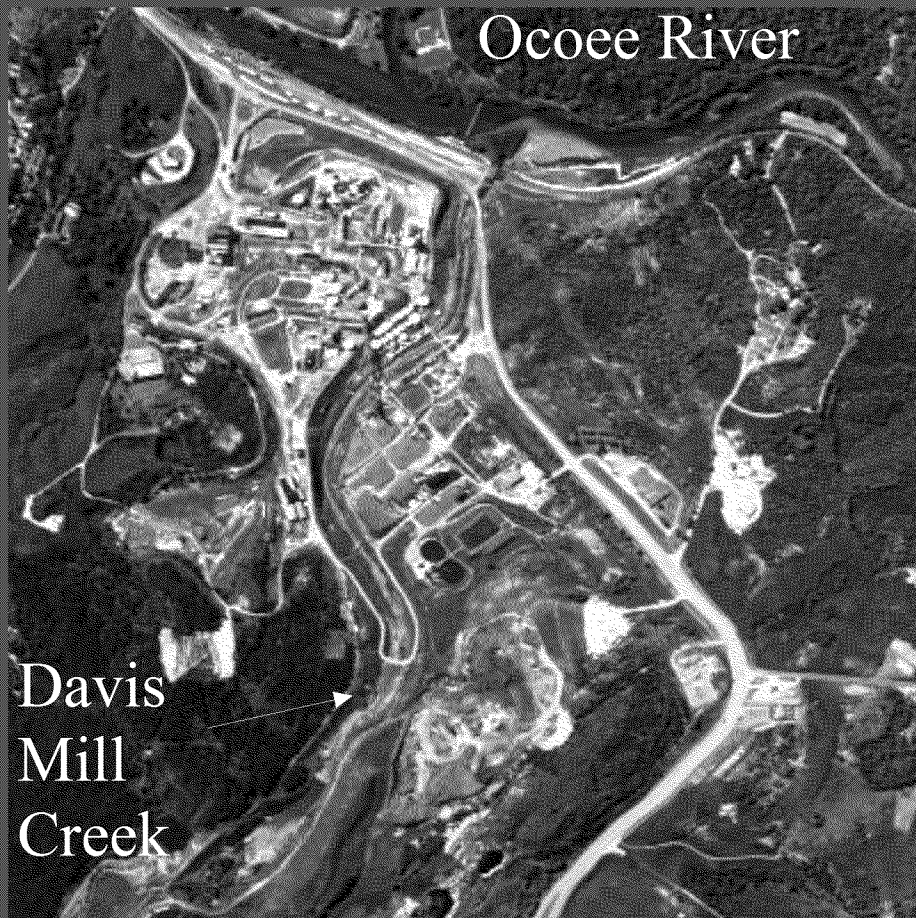
North Potato Creek

Image processing algorithm output
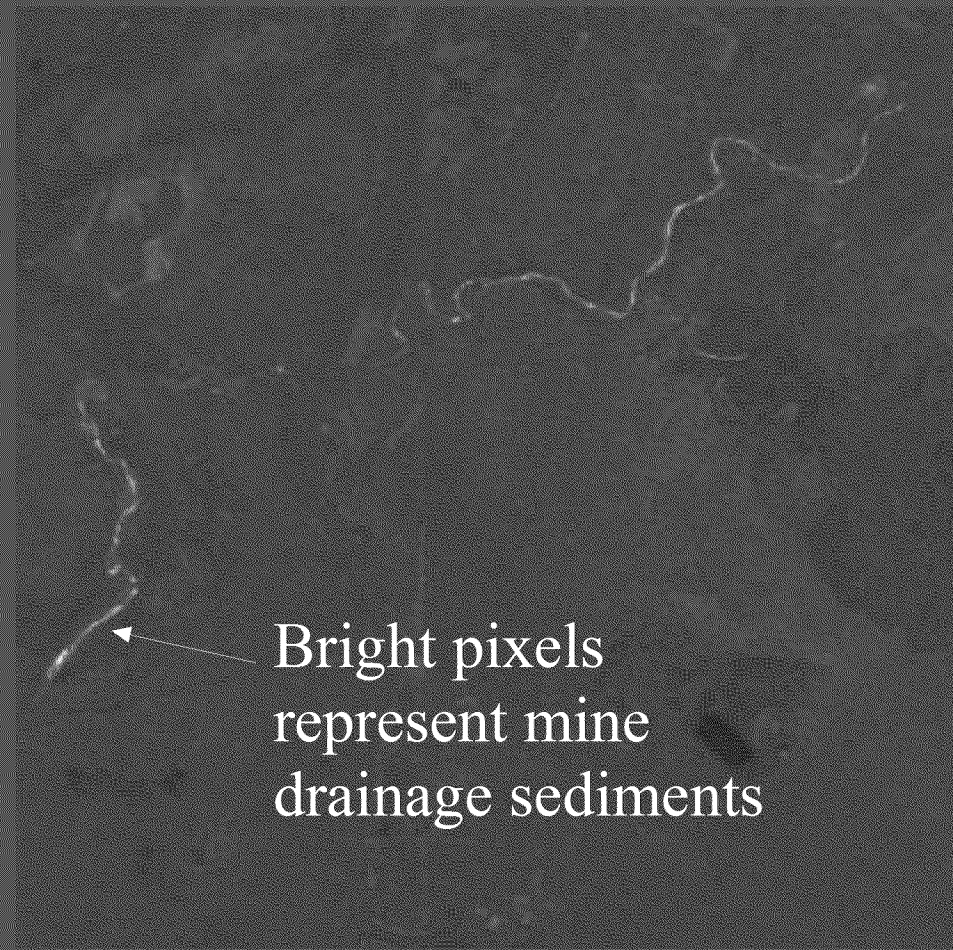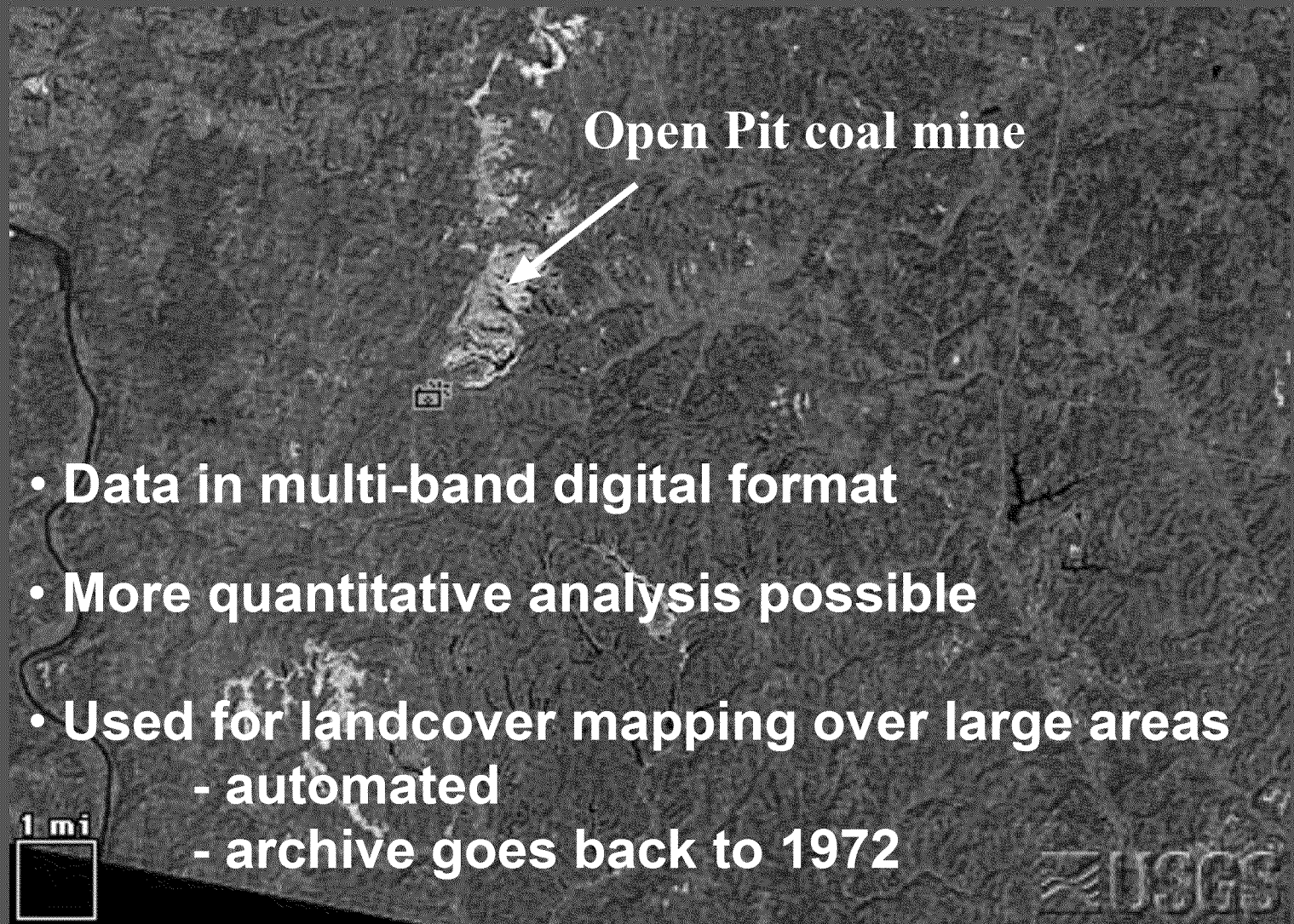
Bright pixels represent mine drainage sediments

Copper Hill

Ocoee River

Davis Mill Creek

Bright pixels represent mine drainage sediments

Future Sensor Systems

- NASA Earth Observing 1 (EO-1) (launch April 13th, 2000)
  - Hyperion Sensor
    - 30 meter pixel resolution
- OrbView-4 by ORBIMAGE an affiliate of Orbital Sciences Corp. (launch late 2000)
  - 8 meter pixel resolution
- ARIES-1 Hyperspectral Resource Mapping Satellite (launch ~2001)
  - 30 meter pixel resolution
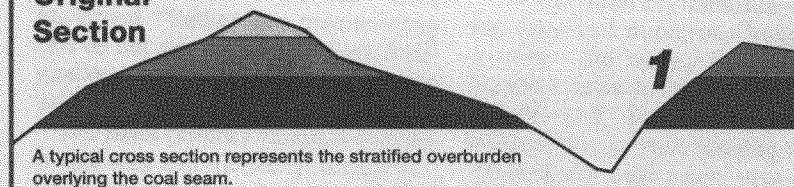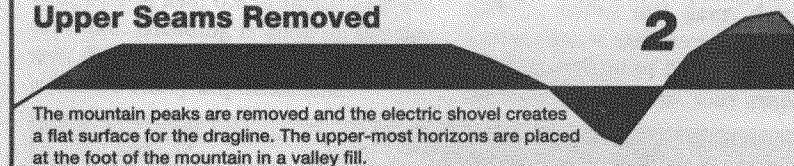
Satellite Multispectral Imagery

Open Pit coal mine

1 mi

- Data in multi-band digital format

- More quantitative analysis possible

- Used for landcover mapping over large areas
    - automated
    - archive goes back to 1972

Mountain Top Removal

Former mountain top

Coal seams

Method of Mining

Hobet's mountain top removal method employs five basic steps.

Original Section   **1**

A typical cross section represents the stratified overburden overlying the coal seam.

Upper Seams Removed   **2**

The mountain peaks are removed and the electric shovel creates a flat surface for the dragline. The upper-most horizons are placed at the foot of the mountain in a valley fill.

Beginning Dragline Operation   **3**

The dragline cuts the first pit and places the spoil on the valley fill.
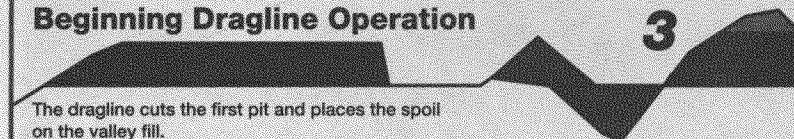
Begin Regrading (Spoil from Cuts 1,2,3 Regraded)   **4**

Each pit is cut, one at a time, and placed in spoil piles across the mountain.

Regraded Section   **5**

When all the coal is removed, a bulldozer regrades the land. Revegetating and reclaiming the land are important to environmental protection.